A LIMITED ENERGY STUDY OF HIGH TEMPERATURE AND CHILLED WATER DISTRIBUTION SYSTEMS AT FORT STEWART AND HUNTER ARMY AIRFIELD, GEORGIA

VOLUME ES
EXECUTIVE SUMMARY

FINAL SUBMITTAL

Prepared For
Savannah District, Corps of Engineers

Contract Number DACA01-94-D-0038
Delivery Order Number 0002

Prepared by
Reynolds, Smith and Hills, Inc.
4651 Salisbury Road
Jacksonville, Florida 32256
(904) 296-2000

Carlos S. Warren, PhD, PE
Project Manager

William T. Todd, PE
Field Survey Manager

September 6, 1996

6941331002

Forces Command	3rd Infantry Division Fort Stewart	Savannah District Corps of Engineers	Reynolds, Smith and Hills, Inc.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
P.O. BOX 9005
CHAMPAIGN, ILLINOIS 61826-9005

REPLY TO
ATTENTION OF: TR-I Library

17 Sep 1997

Based on SOW, these Energy Studies are unclassified/unlimited. Distribution A. Approved for public release.

Marie Wakefield,
Librarian Engineering

1.0 INTRODUCTION

1.1 AUTHORIZATION

Architectural-engineering services for the Energy Engineering Analysis Program (EEAP) - Southeast Region were authorized by the US Army Corps of Engineers, Mobile District Contracting Division under Indefinite Delivery Contract Number DACA01-94-D-0038. Engineering services for the Limited Energy Study of High Temperature and Chilled Water Distribution Systems at Fort Stewart and Hunter Army Airfield were authorized by Delivery Order Number 2 from the Savannah District, Corps of Engineers. Reynolds, Smith and Hills, Inc. (RS&H) received the Notice to Proceed for Delivery Order Number 2 on June 15, 1995.

1.2 OBJECTIVES

The primary purpose of this contract is to conduct a detailed study that will determine the location and quantity of losses from the High Temperature Water (HTW) distribution system at Fort Stewart. A copy of the Scope of Work for this project is contained in the Appendix. This study includes a comprehensive field investigation of the energy plants, distribution system piping and end-use systems, identification of Energy Conservation Opportunities (ECOs), energy savings calculations and economic analysis of the ECOs.

This project also includes interviews with operation and maintenance personnel, review of records and recommendations on whether further study is required on the chilled water distribution system at Fort Stewart and the high temperature water and chilled water distribution systems at Hunter Army Airfield. The results of the analysis and the recommendations are contained in the Records Analysis and Site Survey Plan which was submitted on August 28, 1995.

1.3 WORK ACCOMPLISHED

The entry interview was conducted at the Fort Stewart Department of Public Works (DPW) office on June 28, 1995.

RS&H conducted the initial field investigation, personnel interviews and data collection at Fort Stewart and Hunter Army Airfield on August 3-4, 1995. The results of the preliminary analysis, recommendations for further studies and the detailed field investigation plan for the Fort Stewart HTW distribution system are contained in the Records Analysis and Site Survey Plan submitted on August 28, 1995.

Subsequent comprehensive field investigations that were performed include:

- Survey of the Central Energy Plant (CEP) and collection of samples of domestic hot water from October 2-6, 1995.

- Survey of the CEP, Satellite Energy Plant (SEP), valve pits and mechanical equipment rooms from November 27, 1995 through December 1, 1995.

- Survey of the mechanical equipment rooms and domestic hot water generators from January 16-18, 1996.

- Survey of selected sections of the underground HTW distribution pipes from February 21-23, 1996.

The Interim Report was submitted on February 19, 1996. The Interim Submittal Presentation and Review Conference was held in the Fort Stewart DPW Conference Room on April 17, 1996. The Pre-Final Report was submitted on May 31, 1996.

Energy, water and labor savings calculations, cost estimates and economic analyses have been completed for all of the ECOs. This report contains the field investigation methodology, data analysis, project evaluations, evaluation results, recommendations and project documentation for the HTW distribution system at Fort Stewart.

2.0 FACILITY DESCRIPTION

2.1 GENERAL DESCRIPTION

Fort Stewart is located near Hinesville, Georgia, which is approximately 30 miles southwest of Savannah. The installation is the headquarters for the 3rd Infantry Division, Mechanized. Most of the buildings are barracks, troop support facilities and vehicle maintenance facilities.

2.2 CENTRAL ENERGY PLANT

The CEP is located in Building No. 1412 and contains boilers that produce high pressure steam (HPS) from which the HTW is produced. Steam for all of the HTW production systems and the HTW for distribution Zones 1, 2 and 3 are produced in the CEP. The steam generation system consists of three natural gas/fuel oil-fired package boilers and one stoker-fired wood boiler. A schematic flow diagram of the CEP and the SEP HTW generation systems is presented by Figure 2.2-1.

2.3 SATELLITE ENERGY PLANT

The satellite energy plant contains two cascade heaters and one pair of circulating pumps. Steam from the CEP feeds the cascade heaters to produce HTW for the SEP distribution zone. Circulating pumps distribute the HTW to the five buildings in the SEP distribution zone. These buildings only require HTW for space heating; therefore, the SEP only operates during the heating season.

2.4 HTW DISTRIBUTION SYSTEMS

The 380 degree F HTW supply is pumped from the CEP and SEP through the underground HTW distribution system piping. There are four HTW distribution system zones that provide the heating source for many of the buildings at Fort Stewart. Three of the zones (Zones 1, 2 and 3) emanate from the CEP. The Zone 2 distribution system splits shortly after leaving the Central Energy Plant and serves some buildings to the north (Zone 2N) and some buildings to the south (Zone 2S). The fourth distribution system comes from the Satellite Energy Plant. Basic information on each of the HTW distribution system zones is presented in the following table.

Table 2.4-1 HTW DISTRIBUTION SYSTEM INFORMATION

	ZONE 1	ZONE 2N	ZONE 2S	ZONE 3	SEP ZONE
Length (Miles)	1.7	0.9	1.3	3.3	1.7 *
No. Valve Pits	19	9	15	38	14
No. Exp. Joints	29	26	19	69	29
No. Buildings	70	9	23	26	5

* Includes approximately 0.9 miles of steam supply piping.

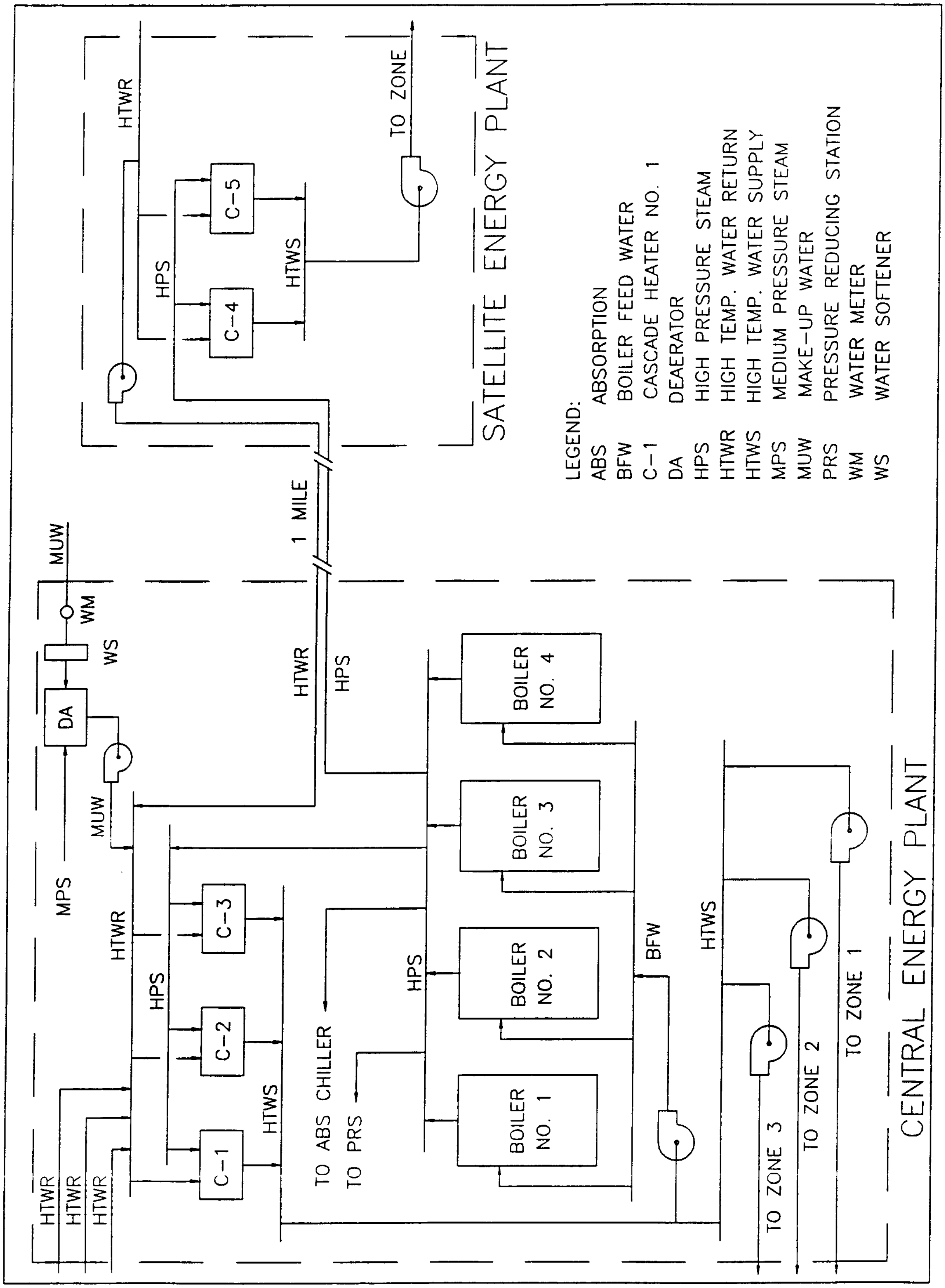


Figure 2.2-1 SCHEMATIC FLOW DIAGRAM

3.0 METHODOLOGY

3.1 GENERAL

The objective of this project is to determine the location and quantity of HTW distribution system piping losses. The total HTW system losses are comprised of these underground piping losses as well as the following: boiler/cascade heater blowdown, soot blowing, leaks associated with Boiler No. 4, CEP leaks, SEP leaks, valve and fitting leaks in valve pits and mechanical equipment room leaks. The field investigation plan was developed to locate and quantify all of these losses.

The field investigation was undertaken and accomplished in three phases. The objective of the first phase was to determine as accurately as possible how much HTW is leaking from the entire HTW system. This was accomplished by surveying the CEP and SEP and measuring and estimating the mass flows into and out of the HTW system. The first phase also included surveys of mechanical equipment rooms to determine how much of the HTW losses are occurring within the buildings served by the HTW system.

Valve pits, drain pits and valve boxes were inspected during the second phase of the field survey effort. This survey determined the location of leaking valves and fittings and also isolated sections of the underground distribution piping where leaks may be occurring. The amount of HTW leaking from the various valves and fittings was also estimated or measured.

The final phase of the field investigation was to locate and quantify the leaks within the underground HTW distribution system piping.

3.2 QUANTIFY HTW LOSSES

Central Energy Plant

The HTW distribution and return system is a closed system. which means that no HTW is consumed by the end-use equipment. The known system losses are steam soot blowing, boiler blowdown, cascade heater blowdown, the deaerator vent and other miscellaneous leaks within the CEP. The total quantity of leaks are estimated by closing all of the soot blowing and blowdown valves and then measuring the flow of makeup water into the HTW system. The amount of makeup water added to the HTW system is a direct indication of how much HTW is leaking out of the system.

The total HTW system losses are equal to the total HTW make-up water. Daily HTW system make-up water data were obtained from the CEP boiler operation logs for calendar years (CY) 93, 94 and 95. These data were statistically analyzed and the results are contained in Section 4.1. The annual average HTW make-up water for CY95 was used in calculations as the total HTW system losses.

Satellite Energy Plant (SEP)

The SEP HTW distribution and return system is also a closed system. The known system loss is the blowdown from the cascade heaters. The total quantity of leaks were estimated by closing all of the blowdown valves and then measuring the amount of HTW lost from the cascade heaters over a two-hour time period. The amount of HTW losses from the two cascade heaters is a direct indication of how much HTW is leaking out of the SEP distribution system.

Valve Pits, Drain Pits and Valve Boxes

There are approximately 95 valve pits located along the main HTW and chilled water (CHW) supply and return lines. The valve pits were visually checked for HTW and CHW leaks around all of the valve stems, flanges and fittings. The volume of flow from each significant leak found was estimated or measured using a beaker and stopwatch.

Steam flowing from the conduit vents on HTW lines where they enter and exit the valve pit indicates a possible leak in the HTW piping. This information was noted and used to isolate sections of the HTW piping for the leak detection and leak locating effort. If there was standing water in the bottom of the pit, a notation was made indicating that the sump pump is not working properly.

Mechanical Equipment Rooms

A survey of the mechanical equipment rooms was not included in the original Scope of Work. However, several HTW leaks were found during a random survey of some of the mechanical equipment rooms. This prompted surveys of the mechanical equipment rooms in all of the 133 buildings served by the HTW distribution system. The survey included checking for HTW leaks around the valve stems, flanges and fittings for the HTW supply and return lines to and from the heat exchangers for the hot water generators, HVAC systems and steam generators. The volume of flow from each significant leak was measured using a graduated beaker and a stopwatch.

A sample of the domestic hot water was obtained from each building that utilizes the HTW system to heat the domestic hot water. These samples were analyzed for conductivity, pH, phosphate, sulfate and iron by a laboratory. The laboratory analysis was compared to the analysis of the HTW and the Fort Stewart potable water supply. If chemicals or compounds that are usually only present in the HTW were found in the domestic hot water, then the heat exchanger has probably failed and is leaking.

3.3 LOCATE LEAKS IN THE UNDERGROUND HTW PIPING

Information obtained during the survey of the valve pits was used to isolate sections of the HTW distribution system suspected of having leaks. The sections of HTW piping suspected of having leaks were systematically surveyed with an electronic leak detection system in an effort to determine as accurately as possible the location of all distribution system leaks. A leak in the HTW piping allows the pressurized fluid to escape. The escaping fluid creates sound frequencies which travel along the pipe.

The leak location technique utilizes two acoustical leak detectors that amplify the audio signals of the leaks and a microprocessor based leak locator. Contact is established between the leak detector transducers and the HTW valves at two valve pits that flank a suspected leak. Distribution information including pipe size and type and measured distance of pipe between the two valve pits are entered into the leak locator. Leak position is shown and evaluated on a video display.

3.4 UTILITY RATES

The utility rates used for the energy cost savings calculations and the economic analysis are presented in the following table. The source that provided the utility information is also listed in the table.

Table 3.5-1 FORT STEWART UTILITY RATES

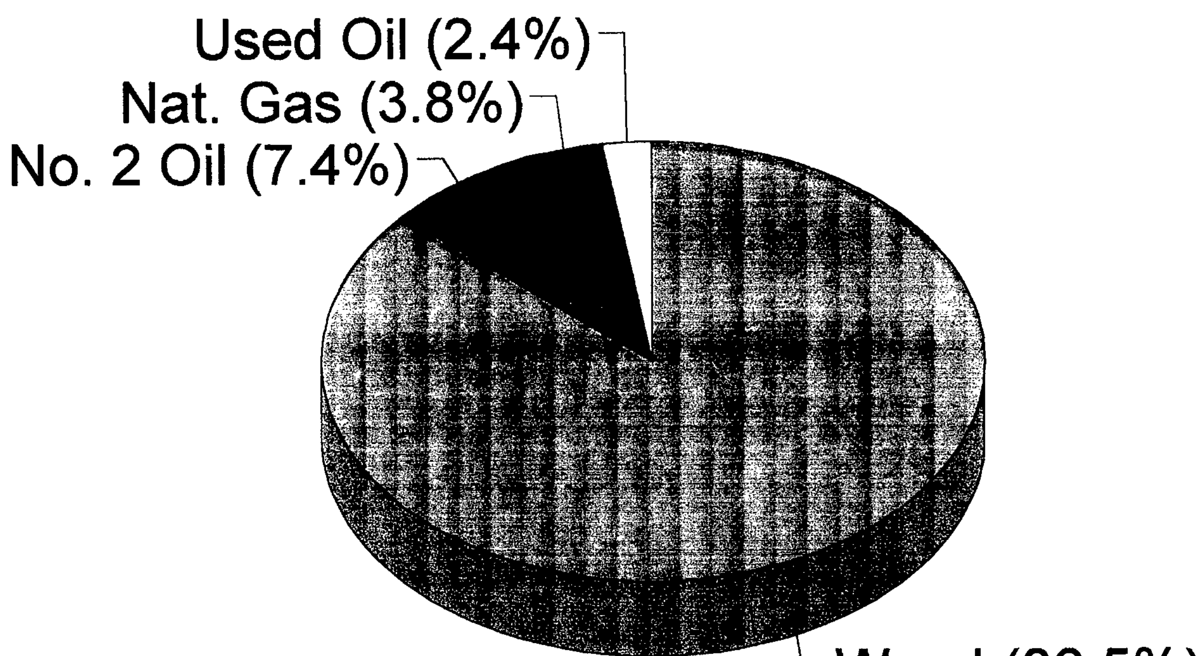
UTILITY	RATE	SOURCE
Electricity	$0.0469/kWh, $13.74/MBtu	Georgia Power Co. Bills
CEP Heating Fuels (Avg)	$1.34/MBtu	Calc. From 12 Months Data
Fuel Oil	$0.62/Gal, $4.40/MBtu	DPW Monthly Oil Reports
Used (Waste) Oil	$0.0/Gal, $0.0/MBtu	DPW Service Branch
Wood	$10.82/Ton, $1.04/MBtu*	DPW Service Branch
Natural Gas	$3.04/MCF, $2.98/MBtu	Atlanta Gas Light Co. Bills
Potable Water	$0.5562/1,000 Gallons	DPW Service Branch

* Assumes a moisture content of 40 percent and a heating value of 5,200 Btu/lb.

The CEP heating fuels rate is an average value calculated from 12 months of CEP energy use data. The CEP heating fuel use make-up is shown in Figure 3.5-1. Wood is by far the dominant fuel used at 87.5 percent, followed by No. 2 fuel oil at 7.4 percent, used oil (from the motor pool) at 2.4 percent and natural gas at 3.8 percent. The utility rates are shown graphically by Figure 3.5-2. The average cost of heating fuels used at the CEP is very low due to the large quantity of inexpensive wood they burn and the use of as much "free" used oil as they can get.

Figure 3.5-1

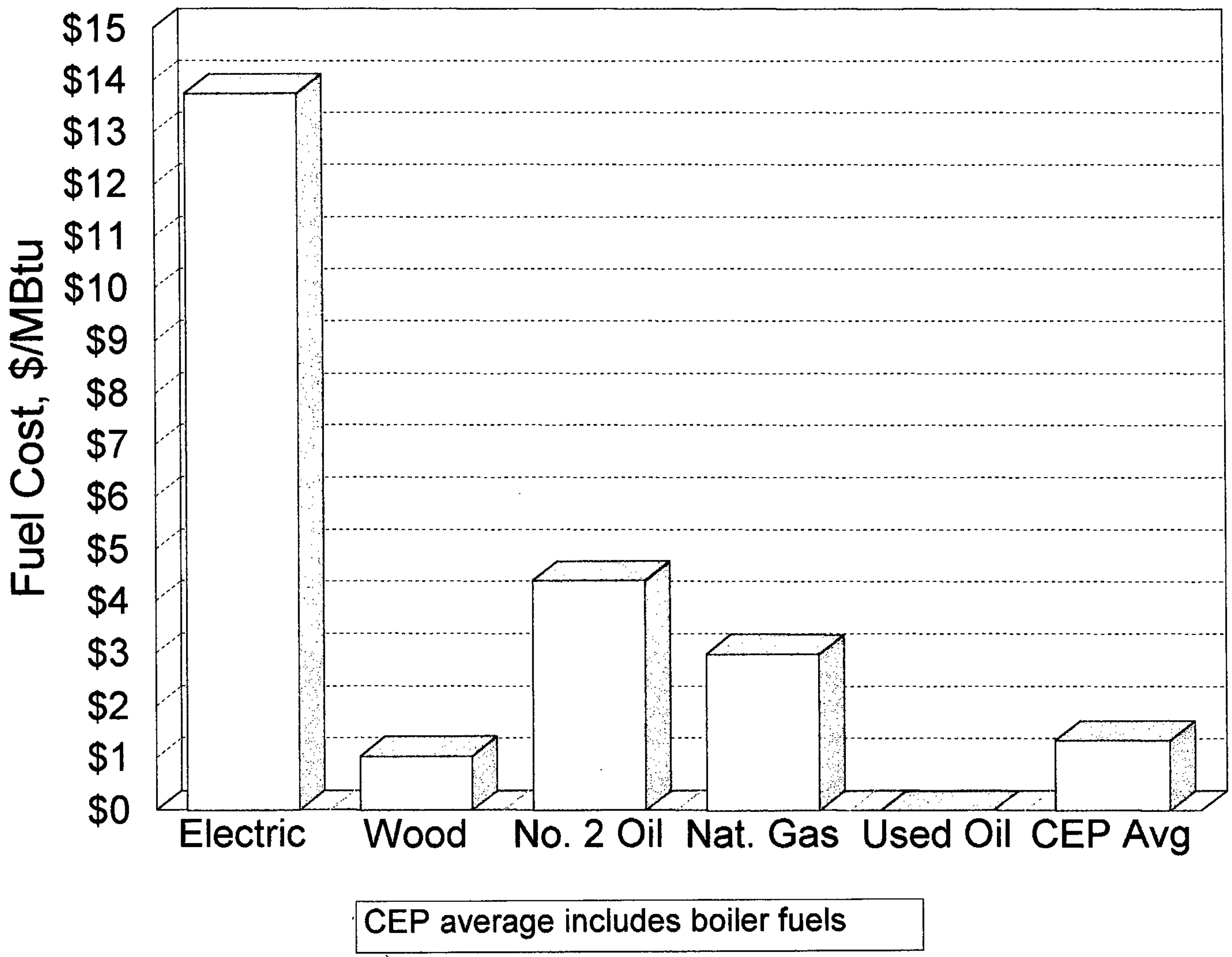
CEP Annual Fuel Consumption, 1994-1995



Total Fuel Consumption = 764,246 MBtu/Year

Figure 3.5-2

Fort Stewart Utility Rates



4.0 ANALYSIS

4.1 HISTORICAL MAKE-UP WATER USE

Make-up water use at the central energy plant is metered as it leaves the water softeners. The total daily make-up water values are recorded on the monthly Facilities Engineering Operating Log for the Central Energy Plant, Building 1412. Copies of the monthly operating logs were obtained for CY93, 94 and 95.

Figure 4.1-1 shows that the 1993 monthly make-up water was fairly constant for ten of the 12 months, averaging between five GPM (7,200 GPD) and ten GPM (14,400 GPD). The frequency (number of days) that various make-up water flow rates occurred and the HTW make-up water statistical data for 1993 are shown in Figure 4.1-2. The make-up water use for 1993 averaged approximately 8.9 GPM (12,800 GPD). There were a total of 15 days in 1993 that had a make-up water use of over 15 GPM (21,600 GPD).

Figure 4.1-3 shows that the monthly and daily make-up water use for 1994 was very erratic, ranging between three GPM and 18 GPM. The frequency (number of days) that various make-up water flow rates occurred and the HTW make-up water statistical data for 1994 are shown in Figure 4.1-4. The make-up water use for 1994 averaged approximately 10.1 GPM (14,500 GPD). There were a total of 66 days in 1994 that had a make-up water use of over 15 GPM (21,600 GPD). The concept for this study was originated during 1994 and these figures show that there was reason to believe that there were substantial leaks in the HTW system at that time.

Make-up water use was significantly lower in 1995 than the previous two years. Figure 4.1-5 shows that the average monthly make-up water flow follows a seasonal profile that would normally be expected. The losses (make-up flow) are higher during the high demand months of mid-winter (heating) and mid-summer (absorption cooling). Soot blowing, blowdown and other miscellaneous plant losses will usually be higher during times of high steam use. The baseline (low end) of the make-up water use for 1995 appears to be approximately 4.5 GPM.

The frequency (number of days) that the various make-up water flow rates occurred and the HTW make-up water statistical data for 1995 are shown in Figure 4.1-6. The make-up water use for 1995 averaged approximately 6.4 GPM (9,200 GPD). There were two days in 1995 that had a make-up water use of over 15 GPM (21,600 GPD) and they were both due to known leaks in the HTW system.

4.2 ESTIMATE OF HTW LOSSES

Theoretically, the losses from the HTW distribution system are equal to the HTW make-up water less all known losses due to blowdown, soot blowing, miscellaneous plant leaks, leaks in valve pits and leaks in mechanical equipment rooms. As described in the previous section, the average HTW system make-up water use for 1995

Figure 4.1-1

Fort Stewart HTW Make-up Water, 1993

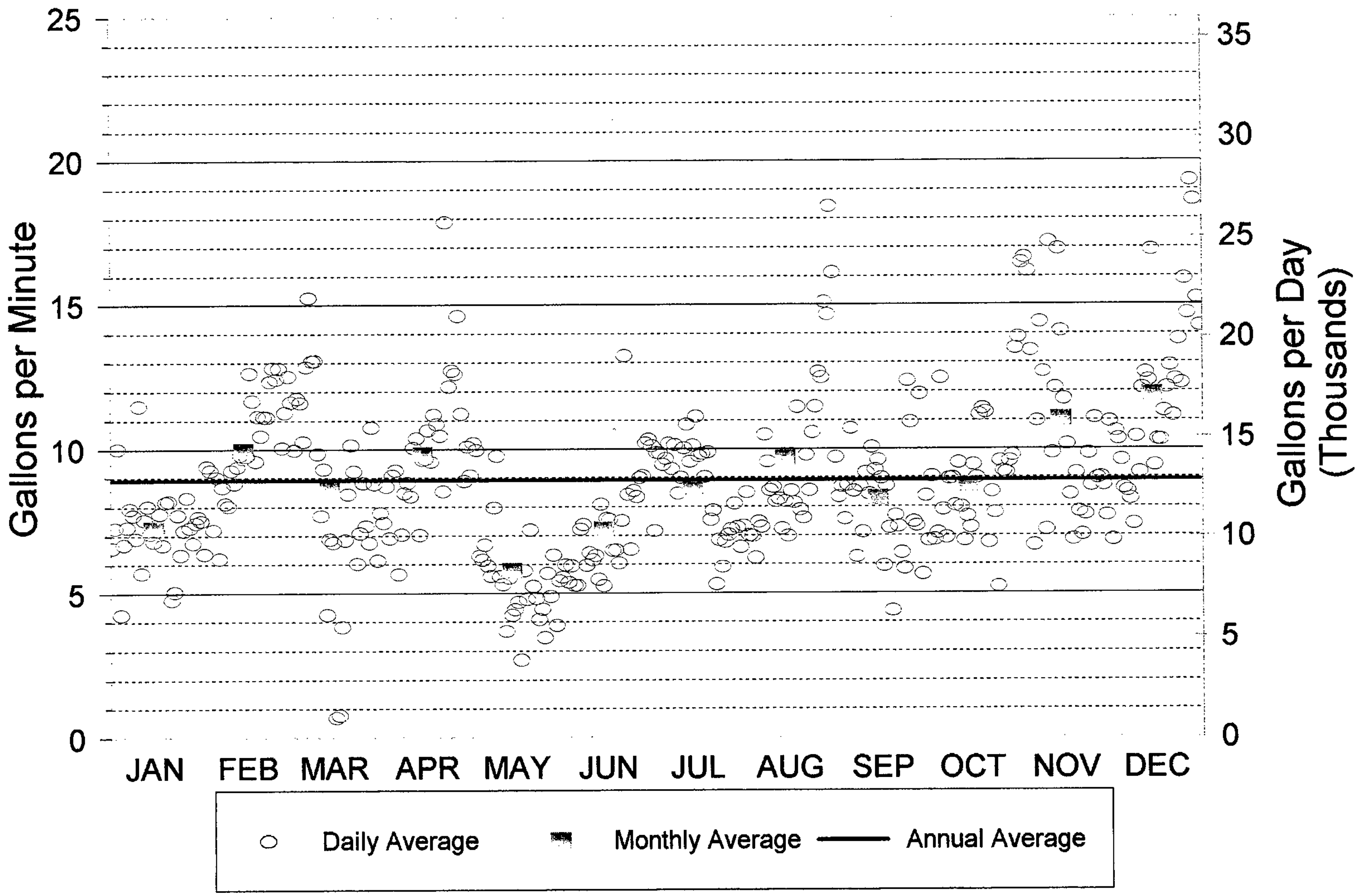


Figure 4.1-2

HTW Make-up Water Statistics, 1993

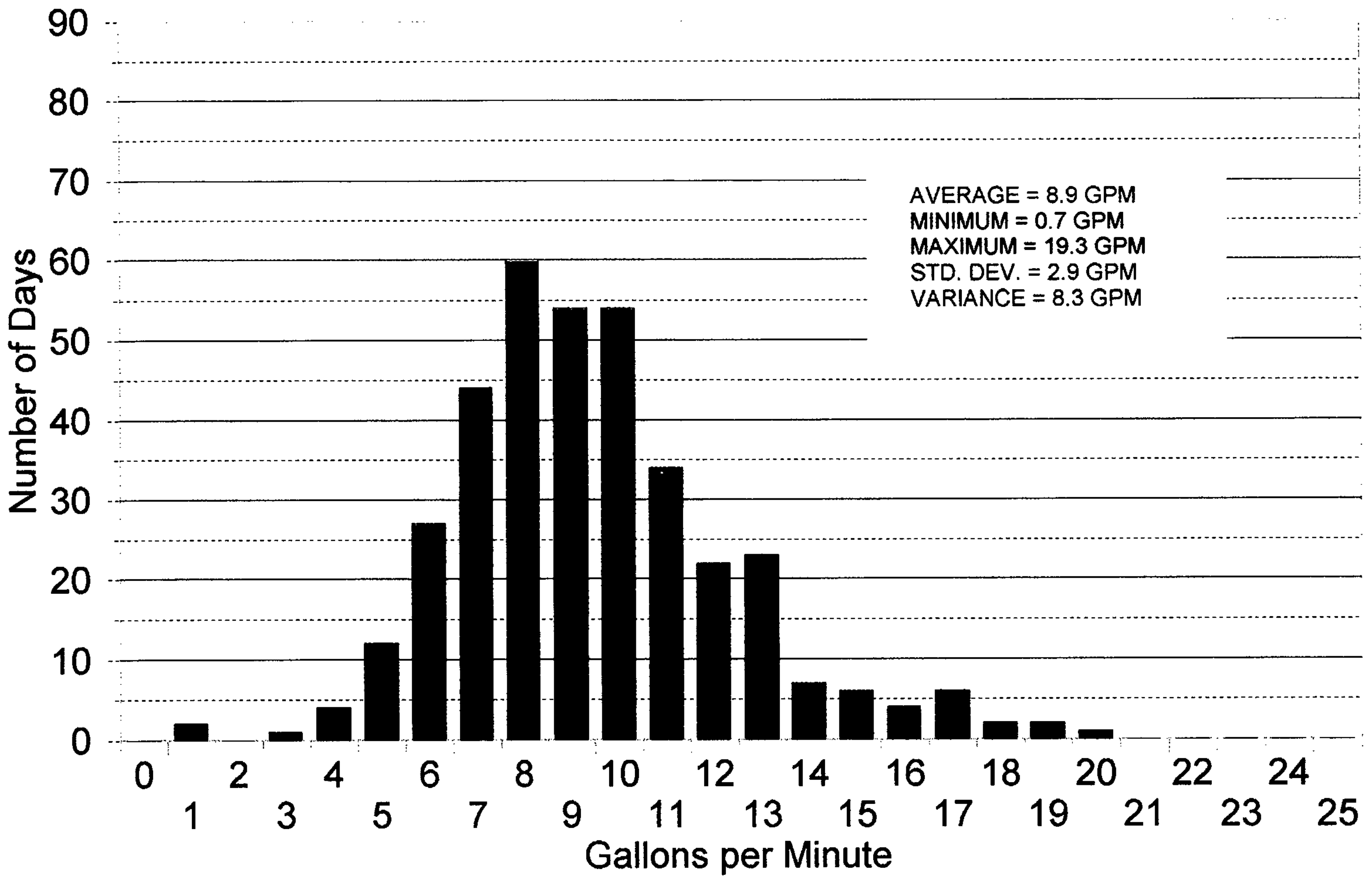


Figure 4.1-3

Fort Stewart HTW Make-up Water, 1994

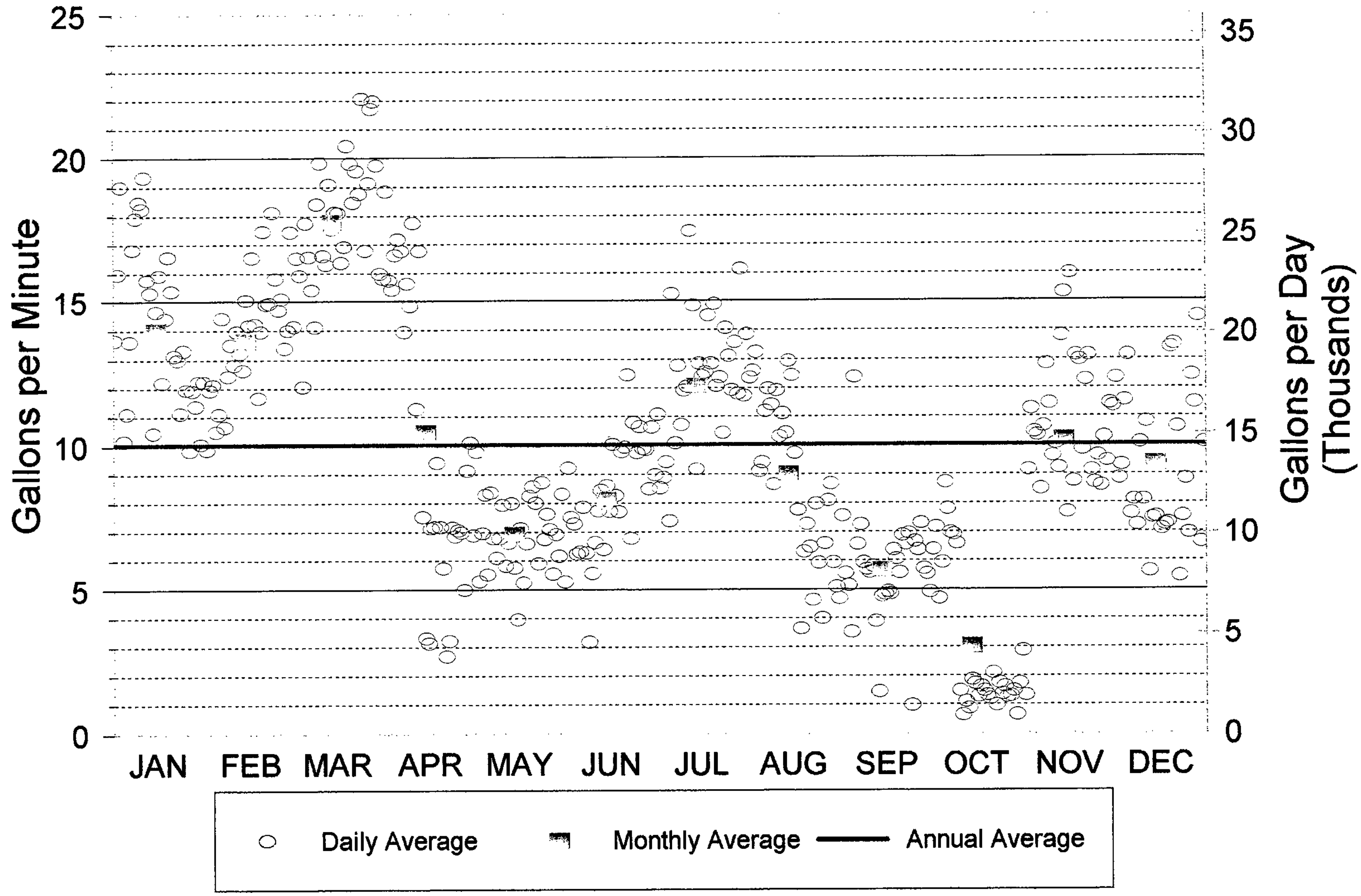


Figure 4.1-4

HTW Make-up Water Statistics, 1994

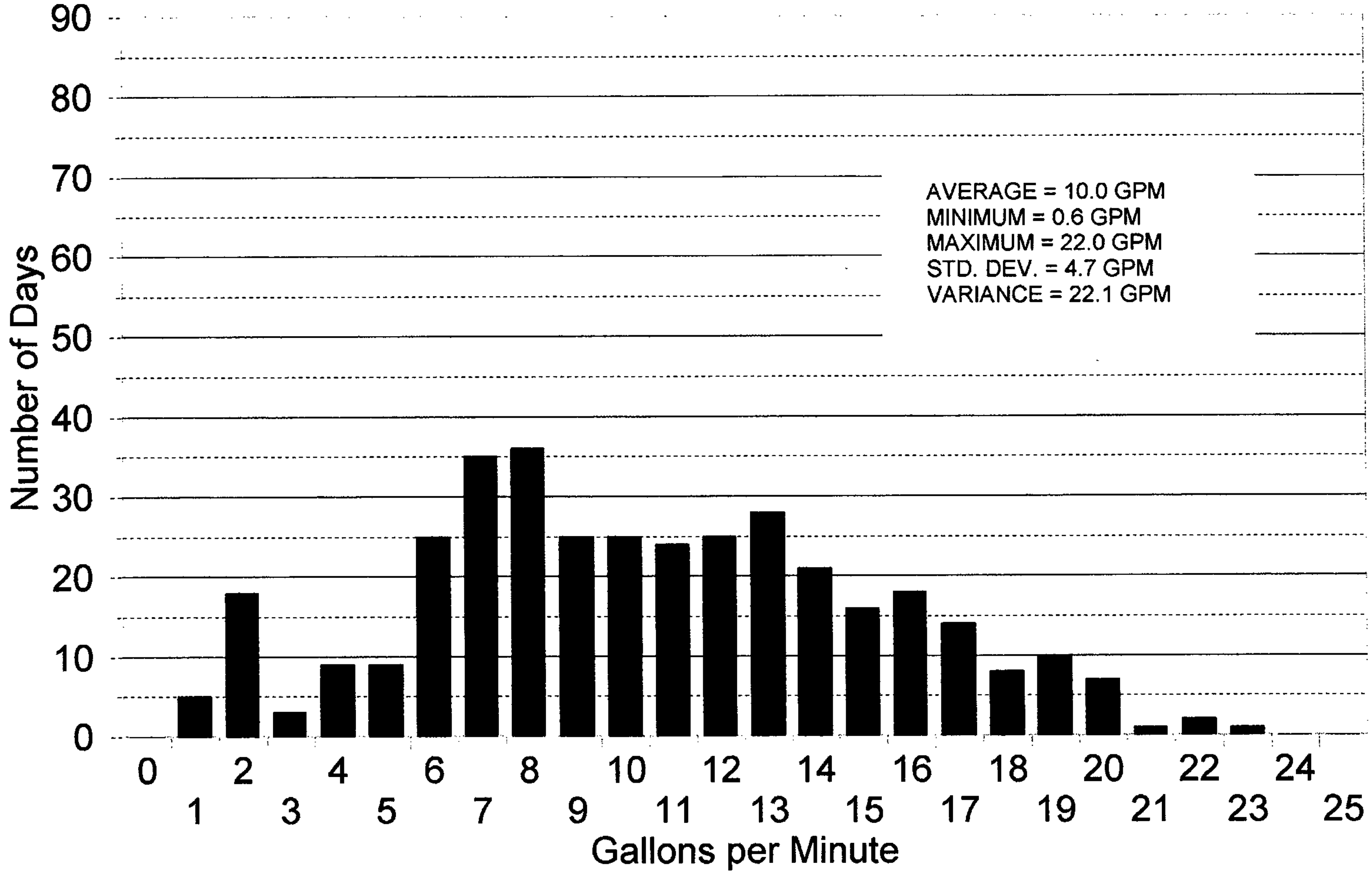
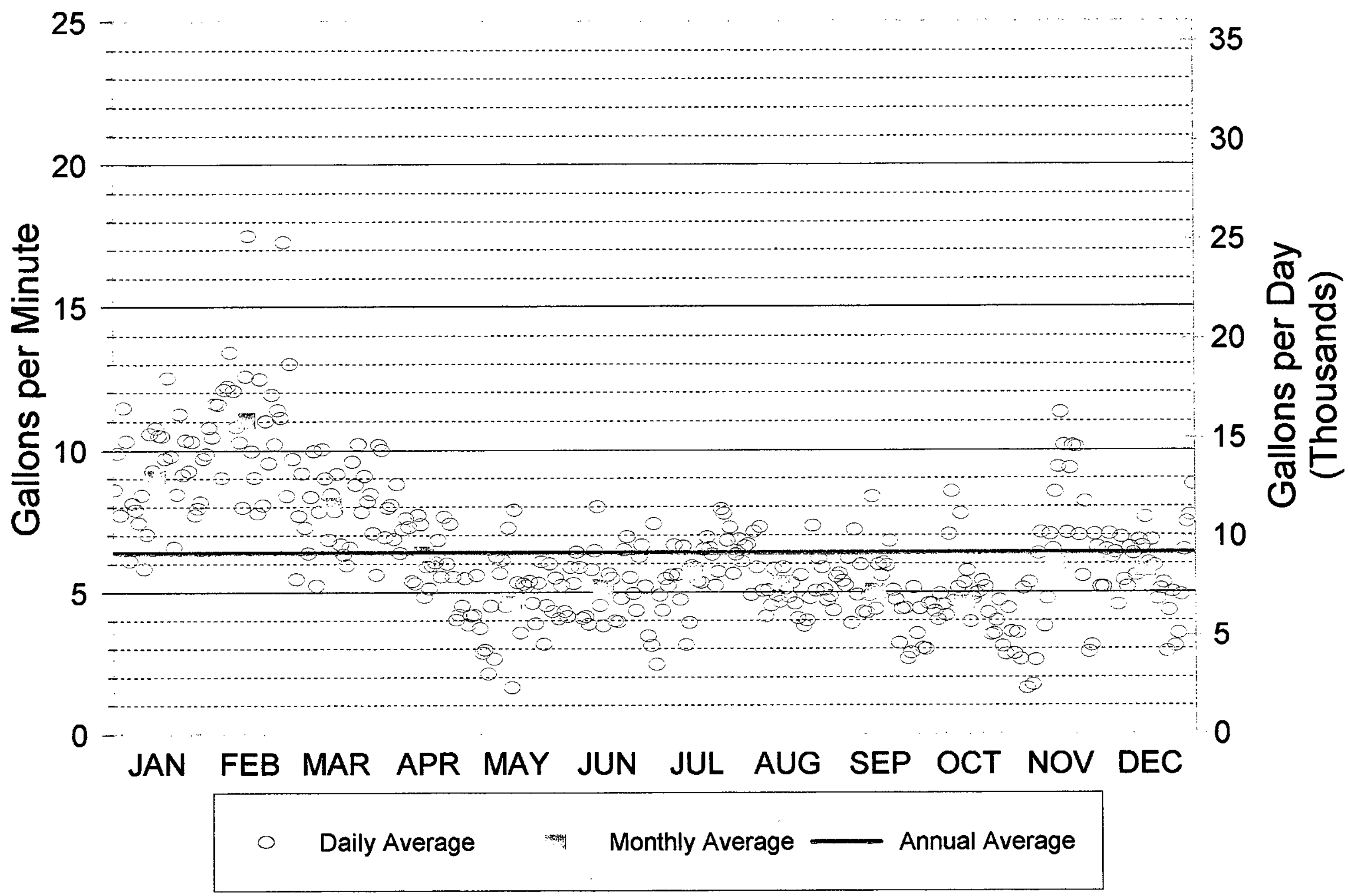


Figure 4.1-5

Fort Stewart HTW Make-up Water, 1995



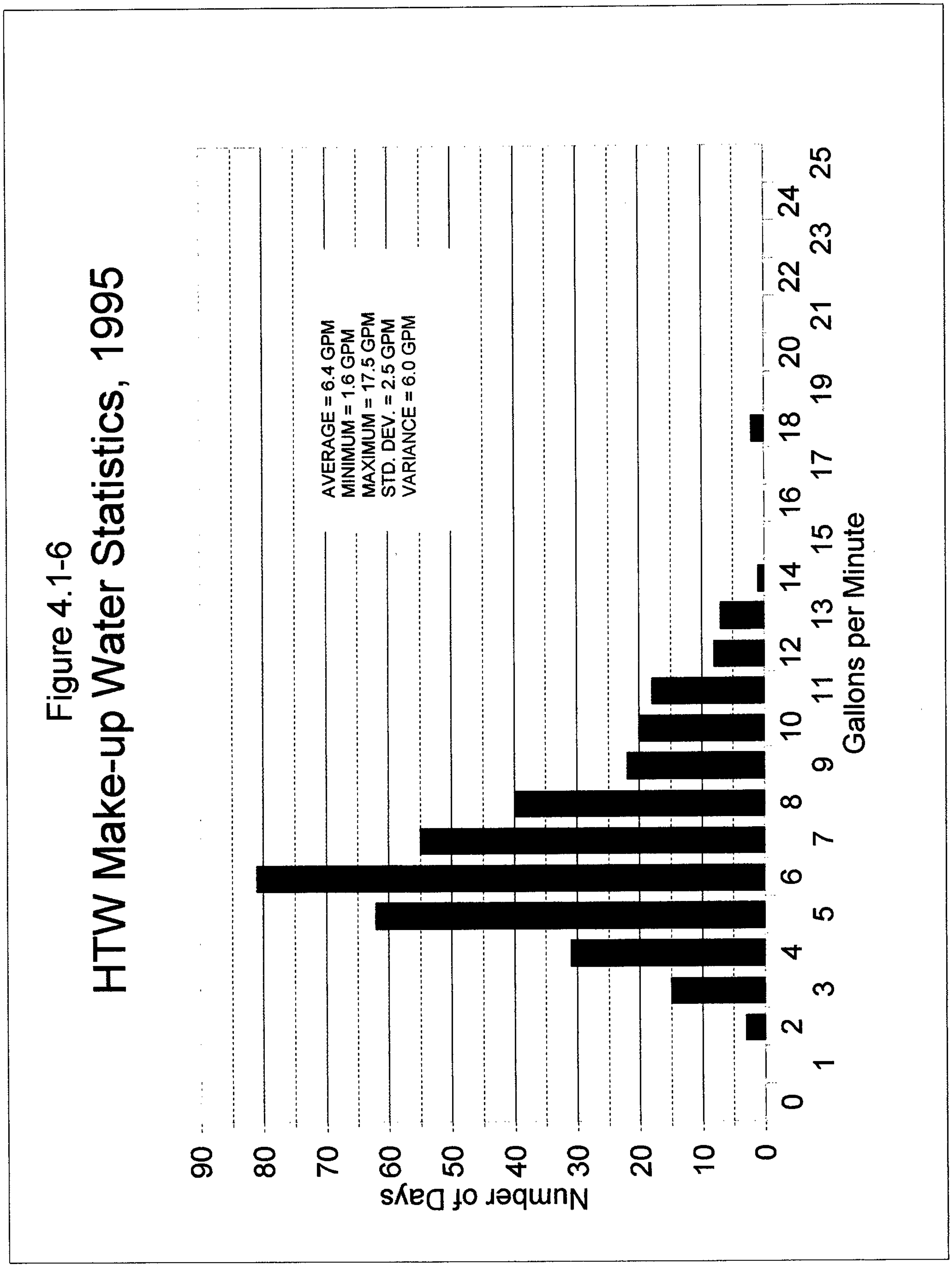


Figure 4.1-6
HTW Make-up Water Statistics, 1995
AVERAGE = 6.4 GPM
MINIMUM = 1.6 GPM
MAXIMUM = 17.5 GPM
STD. DEV. = 2.5 GPM
VARIANCE = 6.0 GPM
Number of Days
90
80
70
60
50
40
30
20
10
0
Gallons per Minute
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

was 6.37 GPM (9,180 GPD) and was considerably lower than the previous two years. Table 4.2-1 lists all of the HTW losses and shows the estimate for the annual average HTW underground piping losses is approximately 1.66 GPM (2,410 GPD).

The results of the CEP leak test yielded a loss of 1,787 gallons in an eight- hour period. This is equivalent to 5,361 GPD or 3.72 GPM. This loss estimate includes the leaks found in the CEP, valve pits and mechanical equipment rooms. Subtracting these losses from the test result provides an estimate of the HTW distribution system leaks during the non-heating season: 3.72 - 0.22 - 0.21 - 0.97 - 0.88 = 1.44 GPM (2,070 GPD). This value compares favorably with the 1.66 GPM of HTW losses calculated and shown in Table 4.2-1.

Table 4.2-1 HTW SYSTEM LOSS ESTIMATES

DESCRIPTION OF LOSS	GALLONS/MINUTE	GALLONS/DAY
Boiler/Cascade Heater Blowdown	1.00	1,440
Soot Blowing	0.33	470
Miscellaneous CEP Leaks	0.21	300
Leaks from Boiler Number 4 Piping	0.22	320
Miscellaneous SEP Leaks	0.23	340
Valve & Fitting Leaks in Valve Pits	0.97	1,400
Mechanical Equip. Room Leaks	0.88	1,260
Heating Equipment and SEP Losses(1)	0.72	1,030
SEP Start-Up Losses(1)	0.11	160
Repaired HTW Piping Leaks(1)	0.04	50
Subtotal Identified Losses(2)	4.71	6,770
Average 1995 HTW Make-up Water	6.37	9,180
Estimated HTW Piping Leaks(3)	1.66	2,410

(1) Losses obtained from the HTW make-up data, could not be visually verified during the survey.

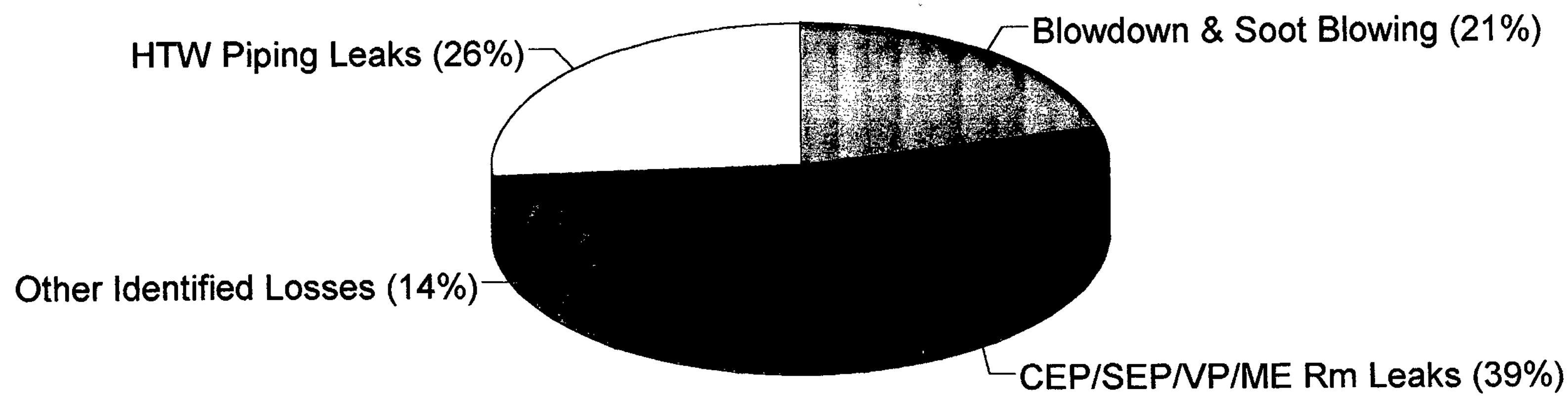
(2) Some leaks may have been repaired or new leaks may have formed since the survey.

(3) Other leaks may include HVAC equipment, hot water generators, equipment repairs, etc.

The estimated losses for the HTW piping distribution system are between 1.44 GPM (2,070 GPD) and 1.66 GPM (3,650 GPD). Figure 4.2-1 shows the percentage of total HTW losses that can be attributed to blowdown and soot blowing, miscellaneous valve and fitting leaks, other identified losses and to leaks in the HTW

Figure 4.2-1

Fort Stewart HTW Loss Estimates, 1995



ANNUAL AVERAGE HTW SYSTEM MAKE-UP WATER = 6.4 GPM underground piping system. The HTW piping leaks represent about 26 percent of the total HTW losses; however, with a total of only about 1.5 GPM of leaks spread fairly evenly over 28 sections of HTW supply and return pipes, the cost of finding and repairing these leaks would be high. The remaining 74 percent of the losses are above ground, accessible and much more cost effective to repair.

4.3 WATER QUALITY AND TREATMENT

Table 4.3-1 lists the results of the boiler and HTW system water analysis for samples taken on July 18, 1995. Causticity and pH are high within their control ranges which is good for general corrosion control. The sulfite is very high for Boiler No. 4 and in the middle of the control range for the HTW supply. This means there is adequate oxygen removal and pitting corrosion is controlled. The very high sulfite level for Boiler No. 4 does not adversely affect the HTW system; however, it does indicate that excessive amounts of sodium sulfite are being added to the system. This is probably due to utilizing the chemical feed system for the boiler to control the sulfite level in the HTW system. The CEP staff should investigate the possibility of installing separate chemical treatment systems for the boiler and the HTW system.

Table 4.3-1 CEP Water Analysis for July 1995

Property	Control Range	Boiler No. 4	HTW Supply	HTW Return
Phosphate	30 - 60	23	N.A.	N.A.
Sulfite	20 - 40	549	30	N.A.
Causticity	20 - 200	120	N.A.	N.A.
Total Diss Solids	3000 - 3500	1400	N.A.	N.A.
Hardness	< 2	N.A.	< 1	< 2
pH - HTWS	9.3 - 9.9	N.A.	9.2	N.A.
pH - HTWR	7.5 - 8.8	N.A.	N.A.	8.7

The value for total dissolved solids is less than half of the low end of the recommended range. This indicates that boiler blowdown is excessive which causes unnecessary losses of water, chemicals and energy. Total dissolved solids is directly related to the quantity of blowdown; therefore, the boiler blowdown should be reduced by about 50 percent.

The CEP staff indicated the causticity would rise when they reduced the blowdown frequency. This may be due to high alkalinity of the make-up water. When blowdown is reduced, the alkalinity in the boiler cycles up causing the causticity to rise. If this is the problem, a de-alkalizer (which is similar to a water softener) could be installed to remove the undesirable alkalinity from the make-up water. This problem should be investigated further by the CEP staff and the water analysis contractor.

The phosphate level in the boiler was below the control range. Corrective action should be taken to prevent scale formation. The phosphate level can be increased by reducing blowdown or increasing the phosphate dosage. Hardness is a measure of the calcium and magnesium in the water. This value is directly related to scale potential. The hardness measurements for the HTW supply and return are both within the control range.

The overall water quality and treatment program at Fort Stewart is good. Implementation of the recommendations described in this section, combined with the current treatment program should provide excellent and efficient corrosion and scale prevention.

4.4 <u>ENERGY CONSERVATION PROJECTS</u>

The following ECOs were evaluated for their technical and economic feasibility.

ECO-1 Replacement of the existing HTW distribution lines with a new shallow trench distribution system.

ECO-2 Reduce blowdown of the cascade heaters and the wood-fired boiler.

ECO-3 Reduce soot blowing, install an exit gas temperature indicator on the wood-fired boiler.

ECO-4 Repair HTW and steam leaks in the CEP and the SEP.

ECO-5 Repair HTW leaks in the mechanical equipment rooms.

ECO-6 Repair building side DHW and HVAC hot water leaks.

ECO-7 Repair HTW leaks in valve pits, drain pits and valve boxes.

ECO-8 Repair underground HTW distribution system leaks.

ECO-9 Reduce or eliminate HTW discharge during SEP start-up.

- Option A. Improve start-up procedure for the SEP.
- Option B. Install a new condensate/HTW return pump in the SEP.

ECO-10 Use an alternative heating method to reduce SEP operating cost.

- Option A. Distribute HTW from the CEP to the SEP instead of steam.
- Option B. Shut down the SEP and use individual oil-fired boilers in the buildings served by the SEP.

ECO-11 Purchase leak locator equipment or contract leak locator service when a major HTW leak occurs.

ECO-12 Reduce boiler and HTW system operating pressure.

5.0 RESULTS AND RECOMMENDATIONS

5.1 RESULTS OF ECO EVALUATIONS

Table 5.1-1 provides a summary of the 12 ECOs and their options that were analyzed for this study.

Table 5.1-1 SUMMARY OF ALL ECO'S

ECO No.	Description	Project Cost $x1000	SIR	Simple Payback Years	Utility Savings (Increase) Electric MBtu/Yr	Htg. Fuels MBtu/Yr	Fuel Oil MBtu/Yr	Water kGal/Yr	Cost Savings (Increase) Energy $/Year	Water $/Year	O&M $/Year	Total $/Year
1	New HTW Piping	$24,612	0.2	99.5	6.5	177,890	0	1,317	$238,460	$730	$8,120	$247,310
2	Reduce Blowdown	$0.50	114.4	0.1	0.0	1,000	0	263	$1,340	$150	$2,360	$3,850
3	Reduce Soot Blow.	$0.23	107.5	0.1	0.0	1,226	0	85	$1,640	$50	$0	$1,690
4	Fix Plant Leaks	$4.54	5.4	2.8	1.5	1,091	0	287	$1,480	$160	$0	$1,640
5	Fix Mech. Rm. Leaks	$4.26	8.5	1.8	2.1	1,612	0	424	$2,190	$240	$0	$2,430
6	Fix HW Leaks	$1.62	18.5	0.8	0.0	1,111	0	956	$1,490	$530	$0	$2,020
7	Fix Valve Pit leaks	$2.78	15.1	1.0	2.4	1,873	0	492	$2,540	$270	$0	$2,810
8	Fix HTW Pipe Leaks	$127.87	0.6	25.6	4.3	3,319	0	872	$4,510	$480	$0	$4,990
9A	SEP Start-up	$0.00	1000+	0.0	0.3	111	0	58	$150	$30	$1,030	$1,210
9B	HTW Return Pump	$32.09	4.3	3.5	0.0	111	0	58	$150	$30	$9,000	$9,180
10A	HTW to SEP	$6.77	22.5	0.7	0.3	111	0	58	$150	$30	$10,070	$10,250
10B	Shut Down SEP	$374.34	(0.2)	71.7	(0.4)	24,711	(9,218)	58	($7,450)	$30	$12,650	$5,230
11	Leak Locator	$55.50	1.5	9.6	0.1	76	0	20	$100	$10	$5,650	$5,760
12A	Oper. at 100 psig	$0.00	1000+	0.0	0.0	30,244	0	0	$40,530	$0	$0	$40,530
12B	Oper. at 60 psig	$29.86	35.5	0.4	0.0	53,115	0	0	$71,170	$0	$0	$71,170
12C	Oper. at 30 psig	$29.86	-10.2	3.7	0.0	110,080	(26,100)	0	$32,670	$0	($24,600)	$8,070

Table 5.1-2 lists the summary information for all of the recommended ECOs. These ECOs were recommended based on the results of the life cycle cost analyses and are listed in order of descending SIR. All of these ECOs have SIRs greater than 1.5 and simple pay backs of less than ten years. ECO-9 Option A and ECO-12 Option A have also been included in the O&M Recommendations in Section 5.2 because they require no capital expenditure. Energy savings for the recommended ECOs are not additive as shown in Table 5.1-2 because the savings for some ECOs are affected by the implementation of others.

Table 5.1-2 SUMMARY OF RECOMMENDED ECO'S													
ECO No.	Description	Project Cost $x1000	SIR	Simple Payback Years	Utility Savings (Increase) Electric MBtu/Yr	Htg. Fuels MBtu/Yr	Fuel Oil MBtu/Yr	Water kGal/Yr	Cost Savings (Increase) Energy $/Year	Water $/Year	O&M $/Year	Total $/Year
9A	SEP Start-up	$0.00	1000+	0.0	0.3	111	0	58	$150	$30	$1,030	$1,210
12A	Oper. at 100 psig	$0.00	1000+	0.0	0.0	30,244	0	0	$40,530	$0	$0	$40,530
2	Reduce Blowdown	$0.50	114.4	0.1	0.0	1,000	0	263	$1,340	$150	$2,360	$3,850
3	Reduce Soot Blow.	$0.23	107.5	0.1	0.0	1,226	0	85	$1,640	$50	$0	$1,690
12B	Oper. at 60 psig	$29.86	35.5	0.4	0.0	53,115	0	0	$71,170	$0	$0	$71,170
10A	HTW to SEP	$6.77	22.5	0.7	0.3	111	0	58	$150	$30	$10,070	$10,250
6	Fix HW Leaks	$1.62	18.5	0.8	0.0	1,111	0	956	$1,490	$530	$0	$2,020
7	Fix Valve Pit leaks	$2.78	15.1	1.0	2.4	1,873	0	492	$2,540	$270	$0	$2,810
5	Fix Mech Rm Leaks	$4.26	8.5	1.8	2.1	1,612	0	424	$2,190	$240	$0	$2,430
4	Fix Plant Leaks	$4.54	5.4	2.8	1.5	1,091	0	287	$1,480	$160	$0	$1,640
11	Leak Locator	$55.50	1.5	9.6	0.1	76	0	20	$100	$10	$5,650	$5,760
	Totals	$106.06	NA	NA	6.7	91,570	0	2,643	$122,780	$1,470	$19,110	$143,360

91,577

A listing of the Non-recommended ECOs is contained in Table 5.1-3. Even though some of these ECOs have SIRs greater than one and simple pay backs of less than ten years, they were not as good as other ECOs and options that provided the same function but offered greater savings.

Table 5.1-3 SUMMARY OF NON-RECOMMENDED ECO'S													
ECO No.	Description	Project Cost $x1000	SIR	Simple Payback Years	Utility Savings (Increase) Electric MBtu/Yr	Htg. Fuels MBtu/Yr	Fuel Oil MBtu/Yr	Water kGal/Yr	Cost Savings (Increase) Energy $/Year	Water $/Year	O&M $/Year	Total $/Year
9B	HTW Return Pump	$32.09	4.3	3.5	0.0	111	0	58	$150	$30	$9,000	$9,180
8	Fix HTW Pipe Leaks	$127.87	0.6	25.6	4.3	3,319	0	872	$4,510	$480	$0	$4,990
1	New HTW Piping	$24,612	0.2	99.5	6.5	177,890	0	1,317	$238,460	$730	$8,120	$247,310
10B	Shut Down SEP	$374.34	-0.2	71.7	-0.4	24,711	(9,218)	58	($7,450)	$30	$12,650	$5,230
12C	Oper. at 30 psig	$29.86	-10.2	3.7	0.0	110,080	(26,100)	0	$32,670	$0	($24,600)	$8,070

The effects of implementing the No Cost/Low Cost projects ECO-9 Option A (revise SEP start-up procedure) and ECO-12 Option A (reduce operating pressure to 100 psig) are shown by Table 5.1-4. Revising the SEP start-up procedure eliminates the energy and water savings provided by ECO-10 Option A. When the operating pressure is lowered, the temperature of the HTW will be lower and the CEP heating fuel savings accomplished by reducing HTW losses will be reduced. Heating fuel savings for ECO-2, ECO-3, ECO-4, ECO-5, ECO-7, ECO-9 Option A and ECO-11 will be reduced by approximately 13.6 percent. Heating fuel savings for ECO-12 Option B will be decreased by almost 57 percent and ECO-6 will not be affected. The revised SIRs and simple pay backs indicate that all recommended ECOs remain eligible for funding.

Table 5.1-4 SUMMARY OF RECOMMENDED ECO'S (With ECO'S 9A &12A implemented)													
		Project		Simple	Utility Savings (Increase)				Cost Savings (Increase)				
ECO	Description	Cost	SIR	Payback	Electric	Htg. Fuels	Fuel Oil	Water	Energy	Water	O&M	Total
No.		$x1000		Years	MBtu/Yr	MBtu/Yr	MBtu/Yr	kGal/Yr	$/Year	$/Year	$/Year	$/Year
9A	SEP Start-up	$0.00	1000+	0.0	0.3	96	0	58	$130	$30	$1,030	$1,190
12A	Oper. at 100 psig	$0.00	1000+	0.0	0.0	30,244	0	0	$40,530	$0	$0	$40,530
2	Reduce Blowdown	$0.50	109.0	0.1	0.0	864	0	263	$1,160	$150	$2,360	$3,670
3	Reduce Soot Blow.	$0.23	93.3	0.2	0.0	1,060	0	85	$1,420	$50	$0	$1,470
10A	HTW to SEP	$6.77	22.1	0.7	0.0	0	0	0	$0	$0	$10,070	$10,070
6	Fix HW Leaks	$1.62	18.5	0.8	0.0	1,111	0	956	$1,490	$530	$0	$2,020
12B	Oper. at 60 psig	$29.86	15.3	1.0	0.0	22,871	0	0	$30,650	$0	$0	$30,650
7	Fix Valve Pit leaks	$2.78	13.3	1.1	2.4	1,619	0	492	$2,200	$270	$0	$2,470
5	Fix Mech Rm Leaks	$4.26	7.4	2.0	2.1	1,393	0	424	$1,900	$240	$0	$2,140
4	Fix Plant Leaks	$4.54	4.7	3.2	1.5	943	0	287	$1,280	$160	$0	$1,440
11	Leak Locator	$55.50	1.5	9.7	0.1	66	0	20	$90	$10	$5,650	$5,750
	Totals	$106.06	NA	1.0	6.4	60,267	0	2,585	$80,850	$1,440	$19,110	$101,400

Implementing ECO-12 Option B (reduce operating pressure to 60 psig) will reduce the heating fuel savings even further. The results of installing this project are shown by Table 5.1-5. Heating fuel savings for ECO-2, ECO-3, ECO-4, ECO-5, ECO-7, ECO-9 Option A and ECO-11 will be reduced by an additional 11.6 percent. Heating fuel savings for ECO-12 Option B will and ECO-6 will not be affected. The revised SIRs and simple pay backs still indicate that all recommended ECOs remain eligible for funding.

Table 5.1-5 SUMMARY OF RECOMMENDED ECO'S (With ECO'S 9A, 12A & 12B implemented)													
		Project		Simple	Utility Savings (Increase)				Cost Savings (Increase)				
ECO	Description	Cost	SIR	Payback	Electric	Htg. Fuels	Fuel Oil	Water	Energy	Water	O&M	Total
No.		$x1000		Years	MBtu/Yr	MBtu/Yr	MBtu/Yr	kGal/Yr	$/Year	$/Year	$/Year	$/Year
9A	SEP Start-up	$0.00	1000+	0.0	0.3	85	0	58	$120	$30	$1,030	$1,180
12A	Oper. at 100 psig	$0.00	1000+	0.0	0.0	30,244	0	0	$40,530	$0	$0	$40,530
2	Reduce Blowdown	$0.50	105.1	0.1	0.0	765	0	263	$1,030	$150	$2,360	$3,540
3	Reduce Soot Blow.	$0.23	82.8	0.2	0.0	937	0	85	$1,260	$50	$0	$1,310
10A	HTW to SEP	$6.77	22.1	0.7	0.0	0	0	0	$0	$0	$10,070	$10,070
6	Fix HW Leaks	$1.62	18.5	0.8	0.0	1,111	0	956	$1,490	$530	$0	$2,020
12B	Oper. at 60 psig	$29.86	15.3	1.0	0.0	22,871	0	0	$30,650	$0	$0	$30,650
7	Fix Valve Pit leaks	$2.78	11.9	1.3	2.4	1,432	0	492	$1,950	$270	$0	$2,220
5	Fix Mech Rm Leaks	$4.26	6.7	2.2	2.1	1,232	0	424	$1,680	$240	$0	$1,920
4	Fix Plant Leaks	$4.54	4.3	3.5	1.5	834	0	287	$1,130	$160	$0	$1,290
11	Leak Locator	$55.50	1.5	9.7	0.1	58	0	20	$80	$10	$5,650	$5,740
	Totals	$106.06	NA	1.1	6.4	59,569	0	2,585	$79,920	$1,440	$19,110	$100,470

Individual programming documentation for FEMP funding was prepared for ECO-4, ECO-5, ECO-6, ECO-7, ECO-10A, ECO-11 and ECO-12B. Low cost/no cost project documentation was prepared for ECO-2, ECO-3, ECO-9A and ECO-12A.

5.2 O&M RECOMMENDATIONS

Central Energy Plant

1. Reduce boiler and HTW system pressure to 100 psig. All that is necessary to accomplish this is to slowly reduce the CEP plant master pressure controller from 180 psig to 100 psig.

2. Inspect boiler No. 4 tubes. The boiler tubes that face the soot blower should be carefully inspected annually.

3. Repair miscellaneous HTW leaks. The operators should be aware of and fix miscellaneous HTW leaks (even small ones) that occur from valves, pumps and fittings in the CEP as soon as they are discovered.

4. Shut off the atomizing steam line when oil is not being used. Boiler Number 4 burns wood about 90 percent of the time.

5. Shut off soot blower steam line. A steam trap located near the bottom of the system appears to be leaking and allowing steam to pass directly to the blow down tank. When the steam trap is repaired this effort will be eliminated.

6. Provide properly operating level controls for all major process vessels.

7. Remove and reinstall the No. 4 boiler rear water wall header blowdown valves. These valves are currently installed backwards.

8. Repair/replace the leaking steam traps on the No. 4 boiler. It was reported that the steam traps on the No. 4 boiler have not received any maintenance since their original installation.

9. Repair the steam turbine driven boiler feed pump (BFP).

Satellite Energy Plant

1. Repair miscellaneous HTW leaks. The operators should be aware of and fix miscellaneous HTW leaks (even small ones) that occur from valves, pumps and fittings in the SEP as soon as they are discovered.

2. Improve start-up procedure for the SEP. Changing the SEP start-up procedures could eliminate the need to discharge HTW and also reduce the labor effort required during start up.

3. Provide status indication of all SEP pumps in the No. 4 boiler control room.

Mechanical Equipment Rooms

1. Inspect mechanical equipment rooms more frequently. The maintenance person should carry a wrench to tighten flanges, fittings and valve stems.

2. Repair and/or adjust domestic hot water temperature controls in Buildings 504, 516, 517, 518, 629, 631, 632, 637, 701, 702 and 1720. The DHW temperature in these buildings ranges from 142 degrees F to 183 degrees F. These controls should be set to maintain a DHW temperature between 120 degrees F and 140 degrees F.

3. Check the heat exchangers for leaks in Buildings 207, 212, 503, 504, 512, 516, 517, 518, 608, 642, 720 and 726. The water analysis for these buildings indicate the possibility of the HTW leaking into the DHW.

Valve Pits, Drain Pits and Valve Boxes

1. Repair or replace inoperable sump pumps.

2. Remove the two trees that are growing in the Zone 3 valve pit located at the west corner where Wilson Avenue intersects West 4th Street.

3. The magnitude and source of the conduit leaks can be determined by installing a drain valve (or threaded pipe plug) in the bottom of the conduit seal plate in the pits. When a leak occurs, chemical analysis would show if the water draining from the opening was ground water or HTW. If the leak is ground water, the valve should be left open so the water can drain out of the conduit instead of being evaporated. This would reduce the thermal losses from the HTW system. If the leak was determined to be HTW, the magnitude of the leak could be measured using a container and a watch. This measurement would provide an objective basis for the economic justification of repairing the leak.